The effect of visuomotor priming of a manual reaching movement during a perceptual decision task in adults with hemiplegia.

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ABSTRACT

Objective: To examine the effect of visuomotor priming of a manual reaching movement during a perceptual decision task after stroke. Method: Forty (n=40) post stroke subjects were recruited and divided into two groups. Following pre test, both the groups trained in reaching proximal and distal object with visuomotor priming (experimental group) or without visuomotor priming (control group).Each participant practiced 24 trials (proximal-12 & distal-12) with affected extremity. Following training, post tests were done on the same day (acquisition phase) and after 24 hours (retention phase).Dependent variables measured include reaction time and number of errors. Results: Significant change in reaction time for experimental group and change in error for both the group. There is statistically significant difference between control and experimental group in performance error during acquisition and retention phase. Conclusion: Visuomotor priming is effective in training hand functions following stroke.

KEYWORDS: Motor learning, visuomotor priming, Reaction time, Hemiplegia, Skill acquisition, Skill retention.

INTRODUCTION

Motor learning is a set of internal processes associated with practice or experience leading to relatively permanent changes in the capability for responding. It is the process of improving the motor skills and the smoothness and accuracy of movements. The cerebellum and basal ganglia are critical for motor learning. Specific motor learning factors are feedback, practice conditions and recovery functions. Feedback is the information that performer receives while performing a task or as a result of performing a task. It will enhance learning by inducing an external focus that will be more effective than those with an internal focus. Intrinsic and extrinsic are divisions of feedback. Intrinsic feedback occurs as a direct consequence of performing a movement. Extrinsic feedback is artificially added and not due to a result of performing a movement. Feedback can be verbal, visual, video and kinematic feedback.

The therapist have to maximize the number of practice attempts to enhance learning. Recovery function is referred to the re-acquisition of movement skills. Optimal function is characterized by the behaviors that are efficient in accomplishing a task goal in a relevant environment.

Factors influencing motor learning are:
(1) State of the Learner; (2) Nature of the Skill ;(3) Methods of Instruction

The State of the Learner refers to the physical and mental condition, nature of the skill encompasses what is required from the learner and methods of instruction refer to the transfer of knowledge from the teacher to the student.

Need for the study:
Arm and hand movement problems are major contributors to disability in patients after stroke. A fully recovered arm of a hemiparetic patient will not improve substantially his quality of life, if it is not accompanied by recovery in the manipulative abilities of the hand. During paretic hand task, the reaching phase was significantly longer for stroke patients .

In recent days, occupational therapists are using various approaches and training methods based on motor learning principles to overcome the performance difficulties. Visuomotor priming is a form of
non-associative learning in which observing the actions of conspecifics leads to predictive motor representations on the side of the observer, even in the absence of the observer’s intention to respond with an imitative or complementary behavior. The behavioral studies suggest that mental simulation of a grasping manual movement sometimes accompanies the visual perception of an object. The relationship between visual perception and motor preparation is mediated by mental simulation of a manual grasp of stimulus; in particular this mental simulation either potentiates the motor response preparation through a visuomotor priming effect or facilitates visual perception through a motor-visual attentional effect.

Earlier study on effect of visuomotor priming is done on hand grasp and release task in adults with hemiplegia. They investigated that visuomotor priming is effective in hand grasp and release task in adults with hemiplegia. Olivier conducted a study on visuomotor priming of a manual reaching movement during a perceptual decision task and found that subjects mentally simulated a manual reaching movement towards the perceived object. No studies have been found to confirm visuomotor priming effect on reaching task in neurological dysfunctional population. Hence, the study has been taken up to test the effectiveness of visuomotor priming in manual reaching movement during a perceptual decision task in adults with hemiplegia whether it can be implemented as a prime treatment modality or as an adjunct in the Post stroke rehabilitation. The primary objectives of this study was to find out the effect of visuomotor priming of a manual reaching movement during a perceptual decision task in adults with hemiplegia.

Methodology

Research Design:
This is a quantitative research design. A longitudinal study to compare the means between two independent groups.

Sample:
This study was conducted on stroke population of various parts of the Chennai and Trivandrum. Forty participants (n=40) were selected through convenience sampling procedure. Each participant was allotted to either experimental group (with visuomotor priming) or control group (without visuomotor priming). Each group consists of 20 subjects.

Screening Criteria:

Inclusion Criteria:
Subjects diagnosed as stroke for the first time, Subjects of above 6 months post stroke, Age 21 - 65 years, Brunnstrom’s recovery stage Fourth and above in arm and hand, A score of 24 or more in Mini Mental Status Examination (MMSE) and normal or corrected vision.

Exclusion Criteria:
Cerebro Vascular Accident (CVA) with history of other neurological problems like Traumatic Brain Injury (TBI), Parkinsonism or other degenerative diseases, CVA associated with orthopedic problems like Trauma, Rheumatoid Arthritis, and Burns, CVA with receptive aphasia, CVA with unilateral neglect, CVA with extra pyramidal deficits, CVA with apraxia.

Materials Needed:
Table and chair, Response device (two parallelepipeds (hand operated switches) fixed on a sheet of wood), Stopwatch, Pencil, Laptop, Visuomotor priming slides, Compact disc.

Tests used for screening:
Mini Mental Status Examination (MMSE), Ideomotor Apraxia test, Pantomime test, Star cancellation test.

1. Mini Mental Status Examination (MMSE):
The MMSE was a brief 30-point questionnaire test, which is used to screen for cognitive impairment. It is also used to estimate the severity of cognitive impairment at a given point in time and to follow the course of cognitive changes in an individual over time, thus making it an effective way to document an individual’s response to treatment. The MMSE is divided into two sections and it requires 5 to 10 minutes to administer. The test is not timed. The first section requires vocal responses only and covers orientation, memory, and attention; the maximum score is 21. The second section tests the ability to name, follow verbal and written commands, write a sentence spontaneously, and copy two overlapping pentagons; the maximum score is 9. The test-retest reliability over a 24 hour period is .89. The inter-rater reliability, using two different examiners with administrations 24 hours apart is .82.

2. Ideomotor Apraxia Test:
The most comprehensive test for eliciting ideomotor apraxia involves imitating gestures. This test contains 10 movements (5 meaningful and 5 non-meaningful gestures) to both verbal command and a copying instruction. The client has to do the movements using the limb ipsilateral to the side of the lesion. Scoring of these tests is 2, 1, or 0, respectively, for correct performance, incorrect but recognizable performance and incorrect & unrecognizable performance.

3. Pantomime Use of Objects:
Most clinicians and researchers use a test for pantomiming use of objects. These tests vary in the type of objects used but are generally presented in three conditions.

i) Verbal instruction:
“Pretend to hold an item and show me how you would use it.”
ii) Visual presentation of the object to the client without touching it: “Show me how you would hold and use one of these”.

iii) Giving the object to the client: “Show me how you would use this”.

The objects used in this test include a hammer, razor, comb, pen, key, and toothbrush. This test helps the clinician to identify where the difficulties lie for particular clients.

Scoring: Scoring of this test is 2, 1 or 0, according to the performance correct, incorrect but identifiable and identifiable respectively.

(iv) Star Cancellation Test:
The Star Cancellation Test is a screening tool that was developed to detect the presence of Unilateral Spatial Neglect (USN) in the near extra personal space in patients with stroke. The test-retest reliability of star cancellation test is .89.

Items: There are no actual items to the Star Cancellation Test. In the Star Cancellation Test, the stimuli are 52 large stars, 13 letters, and 10 short words interspersed with 56 smaller stars. The patient must cross out with a pencil all the small stars on an 8.5" x 11" piece of paper. Two small stars in the centre are used for demonstration. The page is placed at the patient’s midline. The test-retest reliability of star cancellation test is .89.

Procedure for Collection of Data:
Participants those who fulfilled the screening criteria were given the consent form. Those who have consented to participate were allotted to either experimental group or control group. On the day, pretest was done on the task of reaching proximal and distal objects (toothbrush). Participants sat on a chair in front of the table with initial starting position. Initial starting position consisted of paretic hand placed at the centre of the Compact Disc (CD) located on the table, which is situated at 15 cm from the subject. The left hand was laid on the table in a resting position. A toothbrush was placed on the table, 5 cm away from the compact disc. A second toothbrush was placed on the table, 25 cm away from the first one. Participants were instructed to reach the proximal and distal toothbrushes as quickly and as accurately as possible. Three trials of this activity were done. Performance errors (the subject lifted his or her hand before instruction and the number of attempts), Reaction time to reach the proximal toothbrush. (Reaction time was measured by using stopwatch), Reaction time to reach the distal toothbrush were noted for outcome measures. On the same day, practice session was started for the participants of each group separately.

Practice session for experimental group:
Participants were given training in reaching the proximal and distal parallelepiped placed on the response device. The response device is a 40 cm wide square sheet of wood. Two parallelepipeds (measures 7 cm x 2 cm x 2 cm) were placed in the subject’s median sagittal plane. The proximal parallelepiped was located 25 cm away from the first one. Both of them needed a precision grip to be grasped. (Protocol used by Gerard, 2006). A laptop monitor placed just behind the response device in the midline. The colored pictures representing chess board were used as stimuli. These pictures reproduce the visual perspective that the player perceives when looking at the chessboard. One picture represented an empty chessboard was the starting signal for the client. The bishops were placed in the following way, 6 proximal bishops (placed on squares in rows 1, 2 and 3) & 6 distal bishops (placed on squares in rows 6, 7 and 8) were presented twice in a randomized order. A total of 24 trials were used. The clients had to respond with the proximal parallelepiped when the bishop was proximal and with the distal parallelepiped when it was distal. The subjects were instructed to respond as quickly and as accurately as possible.

Practice Session for Control Group:
Participants were given training in reaching the proximal and distal parallelepiped placed on the response device by giving manual instructions for a total of 24 trials.

Post tests: On the same day at the end of the training following 10 min of rest, both experimental and control groups were tested with the outcome measures (acquisition phase). After 24 hrs of acquisition phase, both experimental and control groups were tested with the outcome measures (retention phase).

Data analysis:
The data were analyzed using the Statistical Package for the Social Science (SPSS 20.0 version). A parametric test, repeated measures of ANOVA was used to analyze the difference between the three means of the same group and Post-hoc analysis was done with Tukey HSD Test for proximal response and distal response. Non-parametric, Friedman test was used to analyze the difference between the three means of the same group and Post-hoc analysis was done with Wilcoxon signed rank test for variable error.

RESULTS AND DISCUSSION:
Acquisition phase:
This deals with the ability to reach the proximal and distal object, 10 minutes after the training. Results revealed that, the proximal and distal reaction time remained more or less same in the control group; a significant change in proximal and distal responses (errors) in the control group. Hence, the control group had no significant changes in reaction time but there is a significant change in variable error. The change in variable error may be due to the repetitions of the task. This result agrees with the previous research done by Mackay.
Morgan & Darzi stated that, practice improves learning. Further the results indicated that a significant difference in proximal and distal reaction time in experimental group; a significant change in proximal and distal responses (errors) in experimental group. Hence, the experimental group had shown an improved performance in reaction time and performance. The change in reaction time is consistent with the previous research stated that, visuomotor priming elicited faster reaction time. The change in errors can be attributed to the earlier study done by Vainio, Tucker & Ellis stated that, visuomotor priming elicited better performance.

### Table 1 Comparison of pre test scores of proximal reaction time and distal reaction time between control group and experimental group

<table>
<thead>
<tr>
<th>Category</th>
<th>Proximal reaction time</th>
<th>Distal reaction time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean 't' value 'p' value</td>
<td>Mean 't' value 'p' value</td>
</tr>
<tr>
<td>Experimental group</td>
<td>0.938 -2.106 0.049</td>
<td>1.141 -2.354 0.030</td>
</tr>
<tr>
<td>Control group</td>
<td>1.051</td>
<td>1.306</td>
</tr>
</tbody>
</table>

\[ 't' = \text{Independent 't' test} \ 'p' < 0.05 \]

Table 1 revealed that, the pre test scores of reaction time between the groups showed a significant difference. It is revealed that, the baseline performances were not same and the post test were not comparable. This is because the subjects were not matched by age and gender. Pre test and post test I scores (table 2) of performance (errors) had shown a significant difference between the control and experimental group. Hence, it was found that the experiment group had shown an improved performance than the control group. Earlier study done by Silpa & Ganesh stated that, the performance errors can be modulated by training with visuomotor priming in grasp and release task.

**Retention phase:**

This deals with the ability to reach the proximal and distal object, 24 hours after the training. Results revealed that, the proximal and distal reaction time remained more or less same in control group; the proximal and distal responses (errors) were retained in control group. Hence, the control group had no significant changes in reaction time, but there is a significant change in variable error. The change in variable error may be due to mental practice done by the subjects. This result is consistent with the previous study stated that, mental practice can improve the performance. Results indicated that the reaction time was retained in experimental group; the accuracy of movements was retained in the experimental group. This result is consistent with the previous study done by Jarus & Gutman stated that, the acquiring and retaining simple motor tasks does not require more cognitive processes during learning. In this study, reaching the proximal and distal object is a simple and a common task. The task involved in testing and training is a common day to-day activity which mimics reaching a toothbrush. It does not require much cognitive processes. Retention of motor skill can be best accomplished by training. This result is consistent with the previous study done by Krakauer stated that, the retention of motor learning is best accomplished with variable training schedules.

Table 1 revealed that, pre test scores of reaction time between the groups showed a significant difference. It is revealed that, the baseline performances were not same and the post test were not comparable. This is because the subjects were not matched by age and gender. Post test II scores (table 2) of the performance (errors) had shown a significant difference between the control and experimental group. Hence, it was found that the participant’s proximal and distal performance in accuracy was better retained in the experimental group than in the control group. Mochizuki – Kawai, Midorikawa, Yamanaka, Tagaya & Kawamura demonstrated that, the acquired skill can be retained for a longer duration in learning with visuomotor priming.

The main finding obtained in the present study is that, the reaction time and errors can be modulated by the pictures of the chess board with chess piece. This result is consistent with the research done by Craighero, Fatigai, Rizzolattti & Umiltà, (2008) demonstrated that, the reaction time can be modulated by training with change of colour in the computer screen. Borghi, Bonfiglioli, Lugli, Ricciardelli, Rubichi & Nicoletti, (2007) suggested that, the visual stimuli automatically activate motor information and the specific motor programs have activated.

### Table 2 Comparison of performance (errors) in proximal response and distal response of pre test, post test I & post test II scores between control group and experimental group

<table>
<thead>
<tr>
<th>Test</th>
<th>Category</th>
<th>Proximal response</th>
<th>Distal response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean 'U' Value</td>
<td>'p' Value</td>
</tr>
<tr>
<td>Pre test</td>
<td>Experimental group</td>
<td>2.800</td>
<td>-.326</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>2.900</td>
<td>-1.949</td>
</tr>
<tr>
<td>Post test I</td>
<td>Experimental group</td>
<td>1.500</td>
<td>-1.460</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>1.200</td>
<td></td>
</tr>
<tr>
<td>Post test II</td>
<td>Experimental group</td>
<td>.700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>1.200</td>
<td></td>
</tr>
</tbody>
</table>

\[ 'U' = \text{Mann-Whitney 'U' test} \ 'p' < 0.05 \]
Clinical implications:
This study implies that, the training a task with visual slides can enhance reaction time and performance. Visuomotor priming can be used as an adjunct in the hand rehabilitation process. Visual slides can be used to train daily living tasks to enhance the effective usage of priming as an adjunct in the therapy process. Relatively easier accessibility and availability of electronic devices like camera mobiles and laptops can be used to deploy technological advancement in the therapy process. Thus visuomotor priming is effective in the rehabilitation in clinical as well as community based rehabilitation setups. This study also had its own limitations, an accurate measure of motor performance has not done. Hence, objective measures in terms of reaction time and number of errors were noted.

CONCLUSION:
This study investigated the effect of visuomotor priming of a manual reaching movement during a perceptual decision task in adults with hemiplegia. The findings of this study suggest that, in a sample of hemiplegic population, training with visuomotor priming can improve reaction time and performance. Hence, visuomotor priming is found to be effective in hand rehabilitation in adults with hemiplegia.

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REFERENCES

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